Neutrinos at the Main Injector

(NuMI)

Project Management Plan

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Fermilab

Operated by

Universities Research Association

for the

U. S. Department of Energy

Neutrinos at the Main Injector
Project Management Plan

This Project Management Plan sets forth the plans, organizations and management systems that will be used by Fermilab and the Department of Energy to manage the Neutrinos at the Main Injector (NuMI) Project. This plan will be kept up-to-date by the NuMI Project Management Team.

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Table of Contents

Table of Tables

Table of Figures

Appendices

ABBREVIATIONS USED IN THIS DOCUMENT

ACWP:	Actual Cost of Work Performed
BCWP:	Budgeted Cost of Work Performed
BCWS:	Budgeted Cost of Work Scheduled
BD:	Beams Division
BSS:	Business Services Section
CR:	Change Request
CSP:	Cost and Schedule Plan
DOE:	Department of Energy
DOE-SC:	Department of Energy Office of Science
DOE-FRMI:	Department of Energy Fermi Group
EAC:	Estimate At Completion
EAW:	Environmental Assessment Worksheet
ES&H:	Environment, Safety & Health
FONSI:	Finding of No Significant Impact
FQAP:	Fermilab Quality Assurance Plan
G&A:	General & Administrative (a.k.a. *indirect* or *overhead* costs)
HEPAP:	High Energy Physics Advisory Panel
LOI:	Letter of Intent
M&S:	Materials & Services
MINOS:	Main Injector Neutrino Oscillation Search (E-875)
MOU:	Memorandum /Memoranda of Understanding
NCMO:	NUMI Construction Management Office
NuMI:	Neutrinos at the Main Injector
OPC:	Other Project Costs
PAC:	Physics Advisory Committee
PEP:	Project Execution Plan
PM:	Project Manager
PMG:	Project Management Group

PMP:	Project Management Plan
PPD:	Particle Physics Division
PSAD:	Preliminary Safety Assessment Document
R&D:	Research & Development
SWF:	Salaries, Wages & Fringes
TDR:	Technical Design Report
TEC:	Total Estimated Cost
TPC:	Total Project Cost
URA:	Universities Research Association, Inc.
WBS:	Work Breakdown Structure

1.0 Introduction

This document describes the Project Management Plan (PMP) that Fermi National Accelerator Laboratory (Fermilab) will follow to meet the technical, cost, and schedule objectives of the Neutrinos at the Main Injector (NuMI) Project. The project will be constructed at Fermilab, in Batavia, Illinois and at the Soudan Underground Laboratory, in Soudan, Minnesota. Fermilab is a DOE Laboratory operated under Contract DE-AC02-76-CH-03000 by the Universities Research Association, Inc. (URA). DOE and Fermilab will work together as a team to accomplish the NuMI Project. This PMP for NuMI, a project baseline and execution document, sets forth the plans, organization and management systems that will be used by Fermilab. The PMP is a lower tier document, which complements the Project Execution Plan (PEP). The PEP established the cost, schedule and technical baselines against which project will be measured by the DOE and established the DOE NuMI Project Management structure. The overall project management will be in conformance with DOE Orders.

1.1 Approval and Revision

The PMP is prepared by the NuMI project manager and approved by the Director of DOE Division of High Energy Physics (SC-22.) Revisions to the PMP that are required to incorporate baseline change actions are considered to be approved by virtue of the corresponding baseline change. Revisions to this PMP that are not connected with baseline changes will be approved by SC-22 and the DOE/NuMI Project Manager. The NuMI Project Manager will propose appropriate changes to the PMP and update the document with appropriate factual material that reflects project development (e.g., actual dates that level 3 milestones are accomplished).

1.2 Project Description

The purpose of the NuMI project is to build a facility for studying the physics of neutrinos. The proton beam of the Fermilab Main Injector will be used to produce a very intense neutrino source. The project includes three elements: 1) The design and construction of a beam line and experimental facilities at the Fermilab site; 2) The design and construction of two multi-purpose detectors for the Main Injector Neutrino Oscillation Search (MINOS) experiment (a near detector at Fermilab and a far detector at the Soudan Underground Laboratory); and 3) Modifications to the Soudan Underground Laboratory to accommodate the far MINOS detector. The three elements listed above are briefly described in sections 1.2.1 through 1.2.3.

1.2.1 NuMI Facility

This portion of the NuMI Project, located at Fermilab, includes the use of the Fermilab Main Injector Accelerator as well as conventional construction of beamline facilities and beamline technical components. Additional details are provided in Sections 2.2.1 and 2.2.1. It will produce an intense beam of neutrinos to enable a new generation of experiments whose primary scientific goal is to definitively detect and study neutrino oscillations. The beam will be of sufficient intensity and energy so that experiments capable of identifying muon neutrino (ν_μ) to tau neutrino (ν_τ) oscillations are feasible. A beam of protons from Fermilab's Main Injector will be used to produce the neutrino beam by directing it onto a production target. Interactions of the proton beam in the target will produce π and K mesons, which will decay into muons and neutrinos during their flight through a decay tunnel. A hadron absorber downstream of the decay region will remove the remaining protons and mesons from the beam. The muons will be absorbed by the intervening earth shield while the neutrinos continue through it to the near experimental hall and beyond to the far detector in Soudan, Minnesota. The experimental halls will contain massive detectors specially designed to detect the relatively few neutrinos that will interact in them.

In addition to the underground construction at Fermilab, NuMI will include two service buildings for access and utilities to be located on the surface. The NuMI Facility at Fermilab is fully described in the *NuMI Facility Technical Design Report*.[1]

1.2.2 The MINOS Detectors

Two MINOS Detectors will be constructed. A near detector located on the Fermilab site will provide a measurement of the neutrino rate and energy spectrum near the point where they are produced. A far detector in Soudan, Minnesota will measure these same quantities 730 km from the near detector. Evidence for neutrino oscillations will be sought by comparing the neutrino interaction rates, event characteristics, and energy spectra in the near and far detectors.

The neutrino detectors for MINOS are highly modular. The MINOS far detector consists of a sandwich structure with alternating octagonal planes of plastic scintillator and steel. The baseline detector consists of two “supermodules”. The near detector is of similar construction but smaller than the far detector. Details of the detector design and construction are given in the *MINOS Detectors Technical Design Report*.[2]

1.2.3 The MINOS Experimental Hall at Soudan

The Soudan Underground Laboratory is a unique research site operated by the School of Physics and Astronomy of the University of Minnesota. It is located in the Soudan Underground Mine State Park, where the Minnesota Department of Natural Resources (DNR) preserves the oldest iron mine in Minnesota. The laboratory is located 2300 feet below the surface, on the mine’s 27th level. The NuMI Project includes the expansion and outfitting of the research facility at the Soudan Underground Laboratory to accommodate assembly and operation of the MINOS far detector. The neutrino beam produced at Fermilab will travel 730 km through the earth’s crust to the Soudan Underground Laboratory, where its interactions will be studied using the MINOS far detector. Details of the Soudan Underground Laboratory design and construction are given in the *MINOS Far Detector Laboratory Technical Design Report*.[3]

2.0 Project Objectives and Performance Criteria

This section describes the scientific and technical objectives of the NuMI Project and the performance criteria for achieving them. Cost and schedule objectives are specified in Section 0.

2.1 Scientific Objectives

The probability that a neutrino will oscillate from one type to another is given by the expression

$$P = \sin^2(2\theta)\sin^2\left(1.27\frac{\Delta m^2 L}{E}\right).$$

Here θ is the mixing angle between the two neutrino types, Δm^2 is the difference between the squares of their masses (eV^2), L is the distance traveled (km) and E is the neutrino energy (GeV). For NuMI, L is firmly established by locating the MINOS far detector at Soudan and E is constrained by the NuMI primary beam energy. The parameters $\sin^2(2\theta)$ and Δm^2 must be determined by experiment and the range of possible values for them is referred to as the parameter space for neutrino oscillations. The underlying physics is discussed more thoroughly elsewhere.[2,4] The following sections describe the scientific objectives in exploring this parameter space.

2.1.1 Detection of Neutrino Oscillations

The primary scientific objective of the MINOS Experiment is to definitively detect neutrino oscillations or, if neutrino oscillations do not occur within the region of parameter space accessible to the MINOS experiment, to place stringent new constraints upon where oscillations might occur. The specific region of parameter space to be explored and the methods of detecting neutrino oscillations are fully discussed in *MINOS Detectors Technical Design Report*.[2]

2.1.2 Identification of Oscillation Channel(s)

There are three known types of neutrinos: ν_e, ν_μ, and ν_τ. A fourth, non-interacting type, known as the "sterile neutrino", is suggested by some theories. The NuMI neutrino beam is composed almost entirely of ν_μ. Hence the goal of the MINOS Experiment is to find a clear signal for $\nu_\mu \rightarrow \nu_X$, where X represents one of the other neutrino types. The NuMI neutrino beam will be of sufficient energy to produce τ leptons, which would identify $\nu_\mu \rightarrow \nu_\tau$ oscillations. If oscillations occur, the MINOS detector will identify the non-μ neutrino flavor(s) and thus the oscillation channel(s).

2.1.3 Measurement of Neutrino Oscillation Parameters

If neutrino oscillations are detected, the MINOS experiment will measure the neutrino oscillation parameters Δm^2 and $\sin^2(2\theta)$ for each oscillation channel observed. The beamline will be optimized to search the region of parameter space that the data from recent experiments indicates is most likely to contain the actual parameters for ν_μ oscillations.

2.2 Technical Goals and Project Scope

The NuMI Project will meet the following technical goals in order to enable the MINOS Experiment to attain the scientific objectives described above. Commissioning goals and operational goals for NuMI are shown in Tables 1a and 1b. These are the parameter values that must be achieved for approval to start operations (Critical Decision 4). The operational goals, which are needed for the project to accomplish its scientific objectives, are expected to be reached after several years of operation. While it is a goal to observe NuMI beam neutrinos in the far detector at the earliest stages of operation, it is recognized that Nature's value for neutrino oscillation parameters may preclude detection of neutrinos until substantial (operational-level) proton intensities have been delivered . These commissioning goals shall not require undue radioactivation of the target station components.

Parameter	Measurement	Commissioning Goal
Proton intensity in target hall	Toroid (or equivalent) beam intensity monitor at entrance to the Target Hall	Greater than $1x10^{12}$ 120 GeV protons/spill
Beam alignment	Transverse distributions of the proton beam and secondary beams.	Proton direction established to within 1 mr of the known direction to the Far Detector in the Soudan mine.
Neutrino beam energy	Near detector event energy	Low energy, 2-4 GeV
Cosmic ray muons detected in the MINOS Near Detector	Near Detector data read out through DAQ system	Majority of the 153 Near Detector planes sensitive to muons
Near detector neutrino flux	Charged current event rate in 1.5 ton fiducial region	Observe neutrinos in the Near Detector produced by the NuMI beam
Cosmic ray muons and atmospheric neutrinos detected in each of the two MINOS Far Detector Super Modules	Far Detector data read out through DAQ system	Majority of the 484 planes of the Far Detector sensitive to muons and atmospheric neutrinos.

Table 1(a) Technical Commissioning Goals

Parameter	Measurement	Operational Goal
Proton intensity in target hall	Toroid (or equivalent) beam intensity monitor at entrance to the Target Hall	$4x10^{13}$/spill $3.6x10^{20}$/year
Beam alignment	Transverse distributions of the proton beam and secondary beams.	Neutrino Beam centered on Far Detector to +/-0.2mr
Neutrino beam energy	Near detector event energy	Low energy, 2-4 GeV Medium energy, 4-8 GeV High energy, 8-16 GeV
Near detector neutrino flux	Charged current event rate in 1.5 ton fiducial region	$1.5x10^{-15}$ events/proton
Far detector neutrino flux*	Charged current event rate	$4x10^{-18}$ events/proton
Muon momentum resolution +	Curvature vs. range in magnetic overlap region	14%
Hadron energy resolution +	Test beam	$\Delta E/E = 70\%/E^{1/2} + 8\%$
Detection efficiency for charged current events +	Event length distribution	90% with <4% neutral current contamination

*Assuming 50% reduction from neutrino oscillations

+Applies to both near and far detectors

Table 1(b) Technical Operational Goals

2.2.1 Construction of Neutrino Beamline (WBS 1.1)

A neutrino beamline will be constructed on the Fermilab site. Beamline components will be built for NuMI or recycled from existing beamlines at Fermilab, installed and tested prior to operation. They will produce a neutrino beam aligned with both the near and far experimental halls. The beam will be of sufficient intensity to conduct the long baseline neutrino research in the parameter space discussed in the preceding sections. The beamline design is more fully described in *NuMI Facility Technical Design Report*.[1].

2.2.2 Construction of Experimental Facilities at Fermilab (WBS 1.2)

Civil construction for the NuMI Project at Fermilab will include the underground construction of tunnels and halls to accommodate the beamline components discussed in Section 2.2.1, an experimental hall which can accommodate the MINOS near detector, two shafts for access to the surface and a service building associated with each shaft. All underground construction will include sufficient radiation shielding to ensure compliance with applicable state and federal regulations when the NuMI beamline is operational. The civil construction is more fully described in *NuMI Facility Technical Design Report*.[1].

2.2.3 Construction of the MINOS Detectors (WBS 2.0)

Two detectors will be built, installed and tested for the MINOS experiment. The near detector will be installed in the experimental hall at Fermilab as a single module. Its neutrino detection capabilities will be similar to those of the far detector. The far detector will be installed as two supermodules. The far detector may eventually be upgraded to include either a third supermodule and/or an emulsion detector. The detector design is more fully described in the *MINOS Detectors Technical Design Report*.[2].

2.2.4 Construction of Experimental Facilities at Soudan (WBS 3.3)

An experimental hall will be constructed and outfitted at the Soudan Underground Laboratory. This hall will be capable of accommodating a MINOS detector comprised of three supermodules and an emulsion detector. Work to be performed at the Soudan Underground Laboratory is fully described in *MINOS Far Detector Laboratory Technical Design Report*.[3].

3.0 Project WBS Structure, WBS Dictionary, and Project Funding

The Work Breakdown Structure is shown to Level 2 in Figure 1. The project WBS and management structure reflects the project budget structure. Table 2 provides a WBS Dictionary for each of the WBS elements.

The Total Estimated Cost (TEC) includes the civil construction and technical components for the NuMI Facility (WBS 1.0). The Other Project Cost (OPC) includes construction of the MINOS Detectors (WBS 2.0), initial conceptual design of NuMI Facility (WBS 3.1) and Detector R&D (WBS 3.2) and work at Soudan (WBS 3.3 & 3.4). The sum of the TEC and OPC is the Total Project Cost (TPC).

The NuMI Project draws it funds from both congressionally appropriated TEC line item construction funds and OPC funds, which are included in the appropriations for the operations of Division of High Energy Physics (DHEP) facilities. The TEC funds are released to the NuMI Project Manager under the directive system in effect between DOE and URA, the operator of Fermilab. The DHEP (SC-22) has the responsibility of distributing the Congressionally appropriated operating funds to the various facilities and assigning their purpose. Letters are distributed regularly to the appropriate field offices with these allocations and directions. The allocations and directions are communicated by the field offices to the facility operators, including Fermilab, as appropriate.

The allocations and directions relevant to the NuMI OPC funds are forwarded by the Fermilab Director to the supporting divisions and sections at Fermilab for use by the NuMI Project Manager. Any change to the NuMI OPC funding profile approved in the NuMI Project Execution Plan will be proposed jointly by DOE, the Fermilab Director, and the NuMI Project Manager. A proposed change must consider a revised cost estimate, the revised funding profile, and a revised schedule for consideration and approval as a directed change.

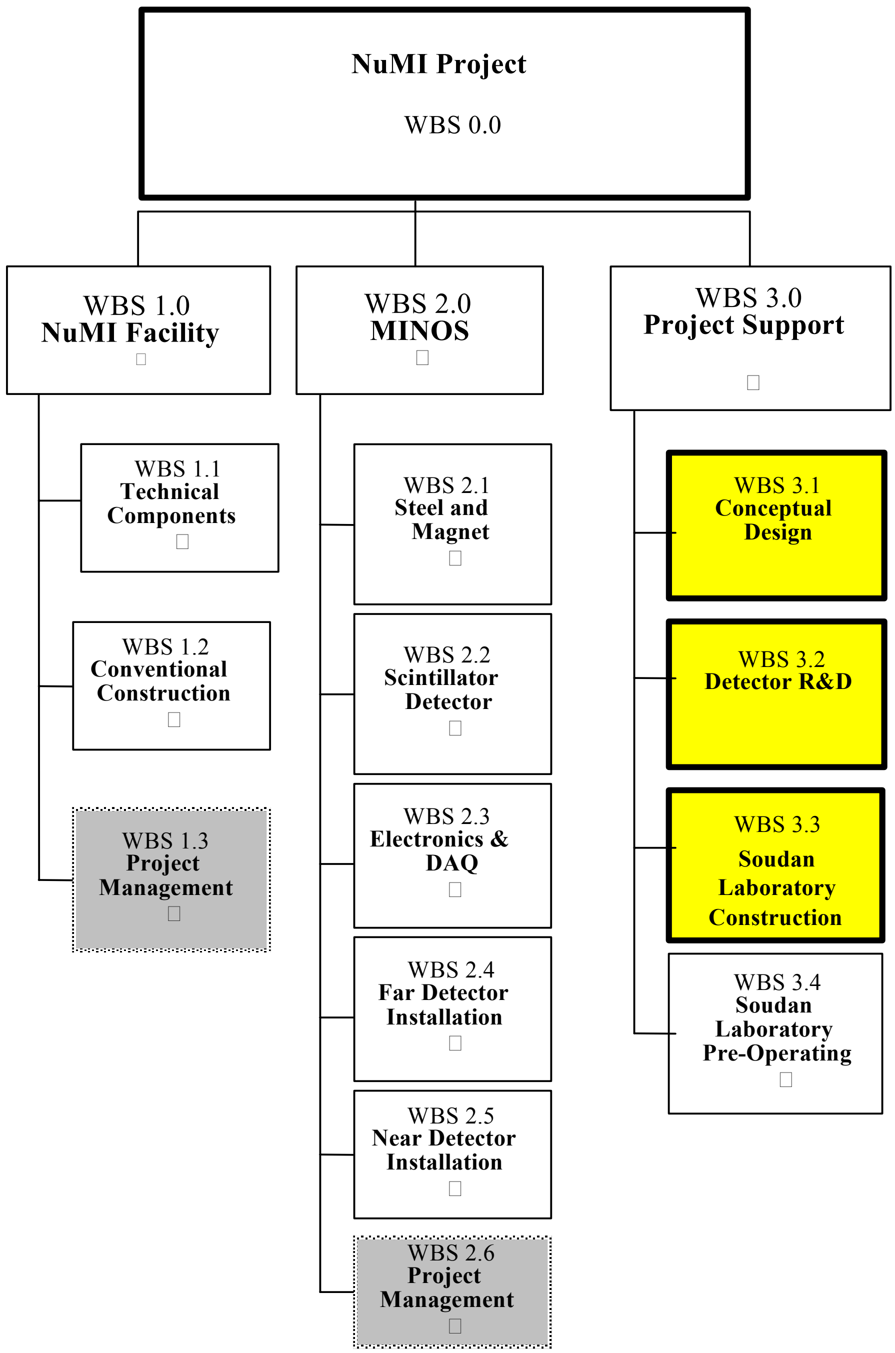

Figure 1 Work Breakdown Structure of the NuMI Project to Level 2.

Gray boxes with dotted lined borders denote elements assigned for management costs only.
Gray boxes with thick lined borders denote completed work elements.

WBS 1.0	**NuMI Facility**	Construct Tunnels and Halls on the Fermilab site, install a proton beam line to carry protons from the Main Injector to a target and construct a secondary beam to produce neutrinos.
WBS 1.1	Technical Components	Design, construct and install the primary proton beam, the secondary neutrino beam, and associated instrumentation, controls, and monitoring.
WBS 1.1.1	Primary Beam	Design and construct or refurbish the components of the primary proton beam extracted from Main Injector to the primary target.
WBS 1.1.2	Neutrino Beam Devices	Design, construct, and install the devices to produce neutrinos focused at the MINOS detectors at Fermilab and Soudan.
WBS 1.1.3	Power Supply Systems	Design, construct or refurbish, and install the power supplies, cables, and connections for NuMI beamline elements.
WBS 1.1.4	Hadron Decay and Absorber Regions	Design, construct and install decay pipe windows and absorber for remaining hadrons.
WBS 1.1.5	Neutrino Beam Monitoring	Design, construct and install systems to measure flux and profiles of secondary beam and muons.
WBS 1.1.6	Alignment Systems	Accurate determination of the proton and neutrino beam centerline at both Fermilab and Soudan.
WBS 1.1.7	Water Vacuum and Gas Systems	Design, construct, and install water, vacuum and gas systems to support the NuMI technical components.
WBS 1.1.8	Cables, Interlocks & Controls Installation	Design, construct and install cables, interlocks and controls system to support the NuMI technical components.
WBS 1.1.9	Hadronic Hose R&D	R&D for meson focusing wire in decay pipe
WBS 1.2	Civil Construction	Design and construct underground Tunnels and Halls at Fermilab to house technical components, near MINOS Detector and two surface buildings to provide access and support services.
WBS 2.0	**MINOS Project**	Design, construct, and install the two MINOS Detectors; “near” at Fermilab and “far” at Soudan.
WBS 2.1	Magnet Steel and Coils	Design and fabricate the steel plates and coils for both the near and far detectors.
WBS 2.2	Scintillator Detector Fabrication	Design and fabricate the active portions of both the near and far detectors.
WBS 2.3	Electronic and DAQ	Design and construct the readout electronics channels and data acquisition systems for both the near and far detector.
WBS 2.4	Far Detector	Install MINOS far detector and its associated

	Installation	infrastructure in the new underground cavern at Soudan.
WBS 2.5	Near Detector Installation	Install MINOS near detector and its associated infrastructure in the new underground cavern at Fermilab.
WBS 3.0	Project Support	Conceptual design and R&D completed prior to project baseline approval. Design, construct, and outfit the cavern at Soudan and support Soudan laboratory operating costs during construction.
WBS 3.1	Conceptual Design	Conceptual design work of NuMI facility prior to project baseline.
WBS 3.2	Detector R&D	R&D work for detector prior to project baseline approval.
WBS 3.3	Soudan Cavern Construction	Includes the construction of the new cavern at Soudan and outfitting including ventilation, utilities. Also includes material handling systems for the far detector. Also includes a surface space for material handling.
WBS 3.4	Soudan Cavern Pre-Operating	Covers certain operating costs at the Soudan laboratory during the MINOS project.

Table 2 WBS Dictionary for NuMI Project

4.0 Project Management Structure

Effective management of the NuMI Project will require careful coordination of the activities of the various organizations involved. The overall project management structure is shown in Figure 2.

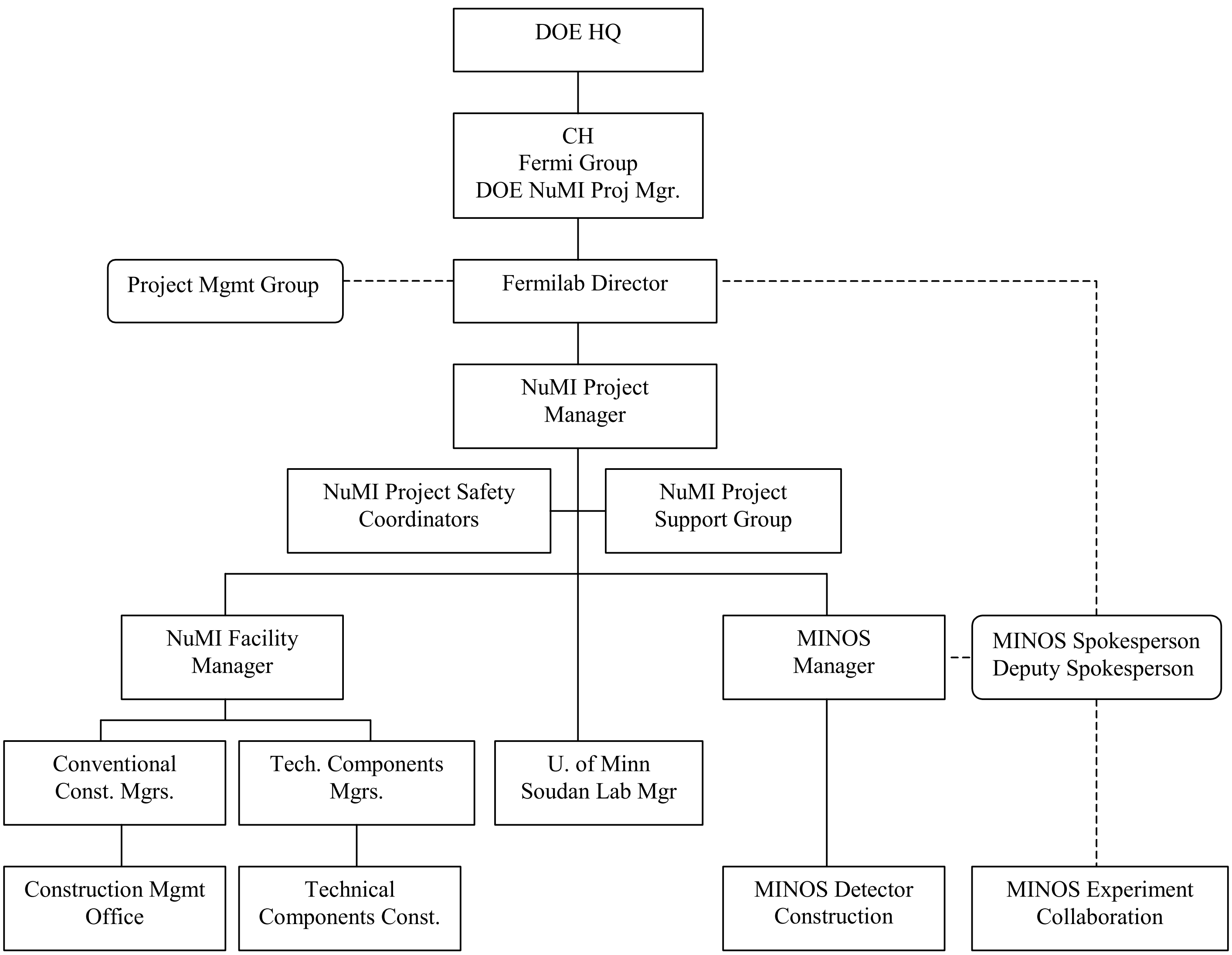

Figure 2 NuMI Project Management Structure**.**

Solid lines indicate direct responsibility. Dotted lines indicate advisory functions. The round-edged boxes are advisory.

4.1 Project Management Philosophy

The multi-faceted nature of the NuMI Project, which includes the construction of a beamline, experimental facilities off-site and experimental detectors, dictates a project management structure that is flexible enough to meet the requirements of these different elements.

NuMI Facility Construction (WBS 1.0), which is covered by the TEC, will be accomplished mainly by Fermilab personnel and subcontractors, with a small amount of the work performed by other research institutions. Major subcontractors will have management and safety plans, which include the project control and ES&H systems described in this PMP.

By contrast, the work on the MINOS Detectors Construction (WBS 2.0) will be accomplished by a combination of the Fermilab PPD and a subset of the institutions of the MINOS collaboration. This work is described in detail in Memoranda of Understanding between Fermilab and the individual collaborating institutions.

Construction, outfitting, and acquisition of surface space at the Soudan Underground Laboratory (WBS 3.3 and 3.4) will be performed by the University of Minnesota and its contractors. This work will be done under MOUs between Fermilab and the University of Minnesota.

The project management structure is somewhat different for each of the three major NuMI WBS elements. The following sections describe the project management responsibilities for the NuMI Project.

4.1.1 Overall Roles and Responsibilities in the NuMI Project

The following roles and responsibilities are applicable to the overall NuMI Project.

4.1.1.1 DOE NuMI Project Manager

In the DOE the management responsibility, authority, and accountability for day-to-day execution of the project has been assigned to the DOE NuMI Project Manager. The DOE NuMI Project Manager is a DOE employee who is appointed by the DOE Fermi Area Office (FAO) Manager, subject to the approval of the Director of the Division of High Energy Physics (DHEP). The DOE Project Manager receives guidance and direction from the DHEP and serves as the principle point of contact for DOE headquarters on issues specific to the project.

Specific responsibilities of the DOE NuMI Project Manager are:

- in cooperation with the DHEP, generate the Project Execution Plan.
- review and approve the Project Management Plan and subsequent revisions.
- implement procedures for baseline management and control, approve changes to Level 2 baselines, and recommend changes or corrective action to baselines above Level 2.
- maintain close contact with the activities of Fermilab to assure that the goals and schedules are met in a timely and effective manner. Review project performance monthly, and keep the DHEP informed of progress (cost, schedule, and technical accomplishments) and problems in a timely manner.
- control the project contingency funds and authorize use within levels established in the Project Management Plan.
- coordinate with the FRMI Manager regarding approval of subcontract procurement actions performed by Fermilab.
- direct the preparation and review of the Preliminary Safety Analysis Document, Title I and II design, Safety Analysis Document, and Environmental Assessment.
- direct the periodic updating of the Project Execution Plan and the Project Management Plan
- coordinate updates of the Construction Project Data Sheets (Schedule 44) for each budget cycle.
- participate in and provide support for the program peer reviews, reviews by oversight committees and validation of the project.

- submit quarterly reports and such other reports on the status of the project for DOE management as required in [the] Project Execution Plan and applicable DOE requirements.
- ensure compliance by the NuMI project with appropriate DOE requirements, e.g., ES&H and contracting regulations.
- issue construction project directives and any modifications thereto.

4.1.1.2 Fermilab Director

The Fermilab Director is responsible to the Universities Research Association and the Department of Energy for the successful completion of the NuMI Project. The Director appoints the NuMI Project Manager. The Director approves and forwards to DOE requests for the authorization of TEC funds. The Director forwards to the appropriate supporting Divisions and Sections the operating funds for OPC obligations as directed by the DOE instructions (see 3.0). The Director approves the experiments which will use the facilities (with advice from the Fermilab Physics Advisory Committee) and plans for the related on-site facilities.

The Director approves the PMP for submission to DOE, and Memoranda of Understanding (MOU). The Director or his designee serves as chairperson of the Project Management Group (PMG).

4.1.1.3 Fermilab Associate Director for Research

The Associate Director for Research is responsible for the administration of the Fermilab Particle Physics Division and the Computing Division. In this position, the Associate Director for Research meets as necessary with NuMI Project management to help allocate resource from organizations reporting to that office.

4.1.1.4 Fermilab Associate Director for Accelerators

The Associate Director for Accelerators is responsible for the administration of the Fermilab Beams Division and the Technical Division. In this position the Associate

Director for Accelerators meets as necessary with NuMI management to help allocate resources from the organizations reporting to that office. As necessary, these meeting are combined with the regular meeting with the Associate Director for Research and the director or his designee.

4.1.1.5 Associate Director for Operations Support

In support of the NuMI Project Manager, the Fermilab Director has delegated the responsibility for coordinating the facilities management activities and overall ES&H/QA oversight of the NuMI Project to the Associate Director for Operations Support.

4.1.1.6 NuMI Project Manager

The NuMI Project Manager is a Fermilab employee who is appointed by the Fermilab Director and is responsible for all aspects of the NuMI Project. The Project Manager reports to the Fermilab Director.

The Fermilab Director has delegated the following responsibilities to the NuMI Project Manager:

- Administering, planning, organizing, and controlling the NuMI Project to meet the project technical, cost, schedule and ES&H objectives;
- Fiscal authority over Fermilab funds allocated to the project;
- Monitoring project expenditures included in the project baseline of other US funds (DOE and non-DOE) and non-US funds;
- Tracking and reporting of deviations from baseline scope, schedules and costs;
- Maintaining and updating the Project Management Plan as needed, with the appropriate approvals of signatories to this document;
- Approval of Technical Design Reports, Memoranda of Understanding and work plans for NuMI Project subprojects.
- Establishing and maintaining mechanisms to carry out the ES&H and Quality Assurance responsibilities of the NuMI Project.

With the agreement of the MINOS collaboration, the NuMI Project Manager serves on the MINOS Executive Committee.

The NuMI Project Manager, in consultation with the Fermilab Director may appoint Deputy Project Managers for appropriate areas.

4.1.1.7 NuMI Project Support Group

The NuMI Project Support Group assists the NuMI Project Manager in the administration of the NuMI Project. It includes a Cost Administrator, a Schedule Administrator, and an ES&H Coordinator, who is assigned to administer ES&H issues and develop the Safety Assessment Document as discussed in Section 8.2.2. A Quality Assurance Coordinator is assigned to administer the NuMI QA Plan, discussed in Section 7.6. The responsibilities of the NuMI Project Support Group encompass the entire NuMI Project.

4.1.1.8 NuMI Project Management Group

The NuMI Project Management Group (PMG) will provide continuing oversight of the entire NuMI Project. The PMG also functions as the Laboratory's Baseline Change Control Board. The PMG is responsible for considering Change Requests that meet the criteria, detailed in Section 4.7 and advising the Director in that regard. The PMG is also a forum for the discussion and assignment of Fermilab resources in support of the NuMI Project. The PMG consists of the following members:

- Fermilab Director (or designee)
- NuMI Project Manager
- MINOS Manager
- MINOS Spokesperson
- Beams Division Head or designee
- Particle Physics Division Head or designee
- Technical Division Head or designee
- Head of BSS or designee

- Head of FESS or designee
- Head of ES&H or designee
- Soudan Laboratory Manager
- DOE Project Manager (Observer)

The NuMI Project Manager serves as secretary of the PMG and prepares its agenda.

4.1.1.9 Fermilab Division and Section Responsibilities

The heads of supporting Divisions and Sections are responsible for supplying the necessary human resources, technical resources, space resources, administration of financial resources and evaluation of ES&H issues that relate to this project.

- The Business Services Section (BSS) is responsible for assisting the NuMI Project in the procurement of materials and/or services, inventory management of property and items acquired by Fermilab and legal advisement as appropriate. Whenever possible, fixed-price competitive procurement practices will be used. After receiving appropriate approval, purchase requisitions are processed by the BSS Procurements Group.
- The Environment, Safety & Health Section is responsible for oversight of ES&H on the Fermilab site and provides the primary contact with DOE-FAO for matters related to site-wide ES&H. Support activities include safety training, assessments and monitoring plans.
- The Facilities Engineering Services Section provides engineering and design support for the NuMI Project, including design, inspection, progress monitoring and payment approval for on-site construction activities.
- The Technical Division provides support in design and construction of magnets and other technical devices.

The roles and responsibilities of the Beams Division and the Particle Physics Division are described in Sections 4.2.1.2 and 4.3.2.6.

4.2 Management of the NuMI Facility Construction

The NuMI Facility Construction comprises the neutrino beamline and all related civil construction, both underground and on the surface, at the Fermilab site. A detailed description of the work is given elsewhere.[1,5]

4.2.1 Roles and Responsibilities in the NuMI Facility Construction

4.2.1.1 NuMI Facility Manager

The NuMI Facility Manger is the Level 1 manager who is responsible for the successful completion of the work on the NuMI Facility construction at Fermilab. NuMI Facility Manager will coordinate the civil construction and the development and installation of the beamline technical components. The NuMI Facility Manager will initiate reviews of NuMI Facility construction activities to ensure that adequate progress is being made and that the technical, cost and schedule objectives are being met.

The NuMI Facility Manager position can be filled by the NuMI Project Manager and should report to the NuMI Project Manager. Since the beginning of the project, NuMI Project Manager has served as the NuMI Facility Manager.

4.2.1.2 Fermilab Beams Division

The Fermilab Beams Division (BD) will operate the NuMI Facility upon completion of the NuMI Project. The BD is the primary source of manpower for beamline development. The NuMI Project Manager is an Associate Head of the Beams Division. The BD has created the NuMI Department for line management of the BD personnel directly assigned to the NuMI Project. The BD Head advises the Fermilab Director on approval of project management documents as they are relevant to BD resources. The BD Head is a member of the NuMI Project Management Group. The BD Head appoints the NuMI Facility Safety Review Committee to review safety concerns within the BD as impacted by the NuMI Project. This committee reports to the BD Division Head.

4.2.1.3 Other Sources of Support

TD, FESS, PPD, ES&H and Collaboration resources may be assigned to provide support for the NuMI Facility construction.

4.2.1.4 NuMI Facility Level 2 Managers

NuMI Facility Level 2 Manager for the Technical Components (WBS 1.1) is responsible for design, fabrication, integration, installation and testing of technical components of NuMI beamline. NuMI Facility Level 2 Manager for the Technical Components is appointed by and reports to the NuMI Project Manager. The Level 2 Manager for the Technical Components is also the Head of the NuMI Department in Fermilab Beams Division. The Level 2 manager advises the NuMI Project Manager on the negotiation of Memoranda of Understanding with outside institutions working on Level 2 element.

NuMI Facility Level 2 Managers for the Conventional Construction (WBS 1.2) are responsible for design, procurement, and oversight of subcontractors and NuMI Construction Management Office (NCMO) staff for the excavation and outfitting of the civil construction part of NuMI Facility. The NuMI Facility Level 2 Managers for the Conventional Construction are appointed by and report to the NuMI Project Manager.

NuMI Facility Level 2 Managers generate the cost-estimate, schedule, and resource requirements for their Subprojects. The Level 2 managers will provide information on cost, schedule and performance for the monthly reports and update their resource-loaded schedules monthly.

WBS 1.3, Project Management, is primarily a budgetary division and is overseen by the NuMI Project Manager.

4.2.1.5 NuMI Facility Level 3 Managers

NuMI Facility Level 3 managers are appointed by the NuMI Project Manager in consultation with the appropriate Level 2 Manager. They are responsible for the design, procurement, fabrication, installation and commissioning of their Level 3 element. Level 3 managers document the scope and baseline of the Level 3 element by maintaining the relevant portion of the NuMI Technical Design Handbook and the NuMI Cost and Schedule Plan. Level 3 managers advise higher level management on the negotiation of Memoranda of Understanding with outside institutions working on their Level 3 element.

4.3 Management of the MINOS Detectors Construction

Construction of the MINOS detectors will be undertaken by Fermilab and by a subset of the other institutions collaborating on the MINOS experiment. A detailed description of the work is given in Reference 2, "*MINOS Detectors Technical Design Report*" and Reference 4, "*Summary of the NuMI Project*".

4.3.1 Memoranda of Understanding

The formal documents that describe the work of the collaborating institutions for MINOS Detectors construction are the Memoranda of Understanding (MOU) between them and Fermilab. The MOU is a general agreement that describes the overall objectives and scope of work to be performed. It is an expression of intent, subject to revision, not a legal contract. A scope of work and resource commitment will be established and described in the MOU for each collaborating institution. The MOU will be signed by:

- The Fermilab Director;
- The NuMI Project Manager;
- The MINOS Manager;
- The MINOS Spokesperson;
- The Principal Investigator from the collaborating institution;
- An appropriate administrative Officer from the collaborating institution.

The negotiation of the MOU is based on the following principles:

- The agreement should utilize the expertise and facilities of the collaborators in such a way as to efficiently meet the technical, cost and schedule goals of MINOS Detectors construction.
- The MOU should ensure that all parties clearly understand their scope of work and have a clear commitment to deliver it on budget and on the schedule required by the MOU.
- The MOU should clearly establish cost, schedule, and deliverables and be consistent with the baseline technical information as specified in the TDR.
- The MOU should establish reporting requirements for technical, cost and schedule information.
- MOU will fully describe the method of funding and staffing for work to be undertaken.
- The MOU delegates certain responsibilities for management and related activities as appropriate to each participating institution.
- The MOU are updated as appropriate, generally through addenda.

4.3.2 Roles and Responsibilities in MINOS Detectors Construction

4.3.2.1 MINOS Manager

The MINOS Manager is a Fermilab employee who is appointed by and reports to the NuMI Project Manager, with the concurrence of the Fermilab Director and the PPD Head. The MINOS Manger is the Level 1 manager responsible for the MINOS Technical Design Report, the MINOS Cost and Schedule Plan and all Memoranda of Understanding for MINOS. The MINOS Manager implements these plans for the construction of the MINOS detectors.

The MINOS Manager monitors all funds allocated to MINOS (WBS 2.0) and is responsible to the NuMI Project Manager for Monitoring those funds. The Fermilab Particles Physics Division has created the MINOS Department within the Particle Physics Division for line management of the PPD personnel directly assigned to the MINOS Detectors construction. The MINOS Manager serves as head of the MINOS Department within the Particle Physics Division and is responsible to the PPD Head for monitoring PPD manpower and technical resources committed to MINOS Detectors construction.

The MINOS Manager, in consultation with the MINOS Spokesperson and the NuMI Project manager, may appoint MINOS deputy manager, Level 2 managers as well as Level 2 deputy managers and Level 3 managers. The MINOS Manager heads the MINOS Management Team (MINOS MT), which consists of the Level 2 MINOS Detector construction managers.

The MINOS Manager will initiate reviews of MINOS activities to ensure that adequate progress is being made and that the technical, cost and schedule objectives are being met.

With the agreement of the MINOS collaboration the MINOS Manager serves on the MINOS Executive Committee.

4.3.2.2 MINOS Detectors Construction Level 2 Managers

MINOS Detectors construction Level 2 managers are appointed by and report to the MINOS Manager. Level 2 Managers are responsible for design, fabrication, integration, installation and testing of all components listed in their Level 2 WBS element. Level 2 managers coordinate collaboration-wide resources via MOU and have the authority to negotiate with all institutions for allocation of these resources.

The Level 2 managers monitor the cost, schedule and performance of their elements. They update their resource loaded schedules and provide a report to the MINOS PM monthly. Level 2 managers are responsible for maintaining quality assurance and for ensuring that their elements meet all relevant ES&H requirements.

4.3.2.3 MINOS Detectors Construction Level 3 Managers

MINOS Detectors construction Level 3 managers are responsible for design, fabrication, integration, installation and testing of all components listed in their Level 3 WBS element.

The Level 3 managers monitor the cost, schedule and performance of their subsystems. They update their resource loaded schedules and provide a report to the MINOS Manager monthly. Level 3 managers are responsible for maintaining quality assurance and for ensuring that their elements meet all relevant ES&H requirements.

4.3.2.4 MINOS Spokesperson

The MINOS Spokesperson communicates the scientific requirements of the MINOS Detectors as well as the neutrino beam design goals. The Spokesperson is the principal point of contact between the MINOS collaboration and Fermilab.

4.3.2.5 MINOS Collaborators

The responsibilities of MINOS collaborators undertaking detector construction assignments are specified in comprehensive MOUs as described in Section 4.3.1. Each MOU details the work that the collaborating institution has agreed to perform for MINOS, including personnel commitments, a budget for the current fiscal year and significant milestones. MINOS collaborators are responsible for adhering to Fermilab rules and procedures while on the Fermilab site.

4.3.2.6 Fermilab Particle Physics Division

The Particle Physics Division (PPD) will operate the MINOS Near Detector and manage the MOU process for the operation of the MINOS Far Detector upon completion of the NuMI Project. The PPD is a primary source of Fermilab manpower and technical resources for MINOS Detector construction. The PPD Head is responsible for line management of Fermilab personnel assigned to the MINOS Detectors construction. The PPD Head also advises the Fermilab Director on approval of project management documents, including MOU for MINOS, as they are relevant to PPD resources.

The PPD Head is responsible for ES&H issues on the Fermilab site for the MINOS Detectors construction and appoints the members of the MINOS ES&H Review Committee. The committee reports to the PPD Head

4.3.2.7 Advisory Functions

The following organizations, while not actually part of the NuMI Project, provide valuable input for management decisions.

4.3.2.7.1 MINOS Executive Committee

The MINOS Executive Committee advises for the MINOS experiment on major scientific and technical decisions, as well as on matters regarding the technical scope of the experiment and its physics goals.

4.3.2.7.2 Special Advisory Groups

The MINOS Spokesperson may form additional groups within the MINOS collaboration to study and advise upon specific technical issues as they arise. Such technical advisory groups provide a means of independent assessment of technical planning issues.

4.4 Management of Construction and Installation at the Soudan Laboratory for MINOS

Construction and outfitting of the experimental hall for the MINOS far detector at the Soudan Laboratory and installation will be carried out by the University of Minnesota (UM) and its outside contractors. This includes the procurement of surface space near the Soudan Mine site. This work will be carried out in accordance with the "Memorandum of Understanding between the University of Minnesota and Fermi National Accelerator Laboratory for Construction of an Experimental Area for and Installation and Operation of the MINOS Detector at the Soudan Underground Laboratory," dated November 6, 1998. The UM leases the Soudan Laboratory from the State of Minnesota and is responsible for personnel safety at the Soudan Laboratory.

4.4.1 Soudan Laboratory Manager

The Soudan Laboratory Manager is appointed by the University of Minnesota and serves at the discretion of the Fermilab Director. This person is responsible for the construction and outfitting of the MINOS cavern and procurement of surface space, reporting to the NuMI Project Manager. This includes coordinating all activities and interactions at Soudan between the NuMI Project, the MINOS Collaboration, the engineering firm providing supervision for the construction and the Minnesota DNR. The Soudan Laboratory Manager is responsible for the preparation and maintenance of design documents, cost estimates, bid packages and a resource-loaded schedule for the NuMI activities at Soudan and will seek approval for all changes to the scope, schedule or cost of the project from the NuMI Project Manager. The Soudan Laboratory Manager will provide monthly progress and cost reports to the NuMI Project Manager. The Soudan Laboratory Manager is a member of the Project Management Group.

5.0 Management Systems and Procedures

This section describes systems and procedures that will be used to manage the cost, schedule and technical aspects of the NuMI Project and the interactions that exist among them. Although various management procedures are described separately here, they are mutually supportive and will be used in an integrated manner. As the NuMI Project evolves, our management systems may be modified in order to operate efficiently under changing conditions. Significant changes will be reflected in a revision of the PMP. Consequently, while the policy and objectives of each management system will remain fixed, the methods, techniques and procedures will be adapted to the needs of the project.

5.1 Reporting

This section describes mechanisms of written communication within the NuMI Project, including regularly issued reports and updates to project management documents.

5.1.1 Project Monthly Reports

Fermilab will provide monthly project reports to the DOE through the DOE Project Manager. The format of the monthly NuMI Project Report may vary but the basic information will include:

- Project Description
- Overview of Project Status
- Master DOE Schedule
- Funding Summary
- Narrative Highlights
- ES&H Highlights
- Level 3 Milestones Status (with Critical Path milestones indicated)
- Variance Analysis
- Cost Performance Reports

5.1.2 Reporting Requirements for the Level 2 and Level 3 Managers

The Level 2 and Level 3 managers provide monthly progress reports to the NuMI Project Manager. Level 3 Managers also provide monthly updates of the Cost & Schedule Plan (CSP) for their elements to the NuMI Project Manager and the appropriate Level 2 Manager. For MINOS elements, the MINOS Manager also receives these updates.

Major subcontracts will provide for reporting which integrates with the Fermilab reporting system. This will help ensure consistent monitoring and control of the subcontracted work. Additional reporting requirements for institutions collaborating in the MINOS experiment are specified in each MOU.

5.1.3 Other Reports

The Technical Design Reports describe the technical baseline of the NuMI Project. The TDRs will be updated and controlled following change approvals and for periodic external reviews. In addition, a set of technical documents (NuMI Notes) is maintained electronically and is accessible to NuMI personnel and collaborators via the World Wide Web.

5.2 Meetings

The following meetings are regularly scheduled to coordinate the efforts of the various elements on the NuMI Project:

- Monthly meetings of the NuMI PMG;
- Weekly Coordination Meetings between the DOE Project Manager and NuMI project management;
- Monthly Coordination Meetings between DOE-SC, the FERMI Group and NuMI project management;
- Weekly meetings of the NuMI Project Manager and the NuMI project support group;
- Weekly meetings between NuMI management and the Fermilab Directorate;
- Weekly meetings between Beams Division Head and NuMI Facility Level 2 Manager for the Technical Components;
- Weekly meetings between Particle Physics Division Head and MINOS Manager;

- Weekly meetings of the Fermilab NuMI Facility Project Staff;
- Weekly meetings of the MINOS Manager and MINOS Level 2 Managers;
- MINOS collaboration meetings occur at least quarterly.

6.0 Project Baseline, Control Levels, and Performance Monitoring

The project baselines and control levels are defined in a hierarchical manner that provides change control authority at the appropriate management level. The highest level of baseline change control authority is defined as Level 0. Changes at Level 0 are approved by the Director of the DOE Office of Science. Changes below Level 0 are approved as follows: Level 1- Director of the DOE Division of High Energy Physics; Level 2 - DOE NuMI Project Manager; and Level 3 and below- Fermilab. Procedures for making changes to the baselines are described in Section 7.0.

The technical, cost, and schedule baselines (as approved in the December 2002 re-baseline,) and the associated control levels are given in Table 3. The project technical baseline is defined at Levels 0-2 by Section 3 of the PEP and at Levels 3 and 4 in the three Technical Design Reports and Handbook. The cost baseline is given at Levels 0-2 in Table 4, and is maintained at more detailed WBS levels in the Baseline Cost & Schedule Plan (CSP), as described in Section 6.2 of this document. The baseline master schedule is shown as Figure 5, and a more detailed schedule is maintained in the Baseline CSP. Controlled milestones are given Appendices A and B. Table 5 shows the planned funding profile for the entire NuMI Project.

	Level 0 Director, Office of Science	**Level 1** Director, Div. of HEP	**Level 2** DOE Project Manager	**Level 3** Fermilab Director	**Level 4** NuMI Project Manager
Technical	Construction of a world class facility for studying the physics of neutrino systems	Scientific and technical objectives, commissioning goals, and design parameters as defined in the PEP, Sections 3.1 and 3.2	Project scope as identified in the PEP, Section 3.3	Major change in scope as defined in TDRs and TDH's (see Table 6)	Minor change in scope as defined in TDRs and TDH's (see Table 6)
Cost	Any change to the TEC or TPC (See PEP Table 8.2)	Any change exceeding $5M at change control Level 1 (See PEP Table 8.2)	Any change exceeding $2M at change control Level 2 (See PEP Table 8.2)	Any change exceeding $100K	Any draw on contingency is reported to the DOE NuMI PM. Any draw exceeding $100K is approved by the DOE NuMI PM.
Schedule	Any change to Level 0 milestones (See Appendix B)	Any change to Level 1 milestones (See Appendix B)	Any change to Level 2 milestones (See Appendix B)	Any change exceeding 90 days to Level 3 milestones (See Appendix A)	Any change exceeding 60 days to Level 3 milestones (See Appendix A)

Table 3 Baseline Change Control Levels.

Cost control levels are shown for transferals between WBS elements; all contingency utilization is subject to approval by the DOE Project Manager.

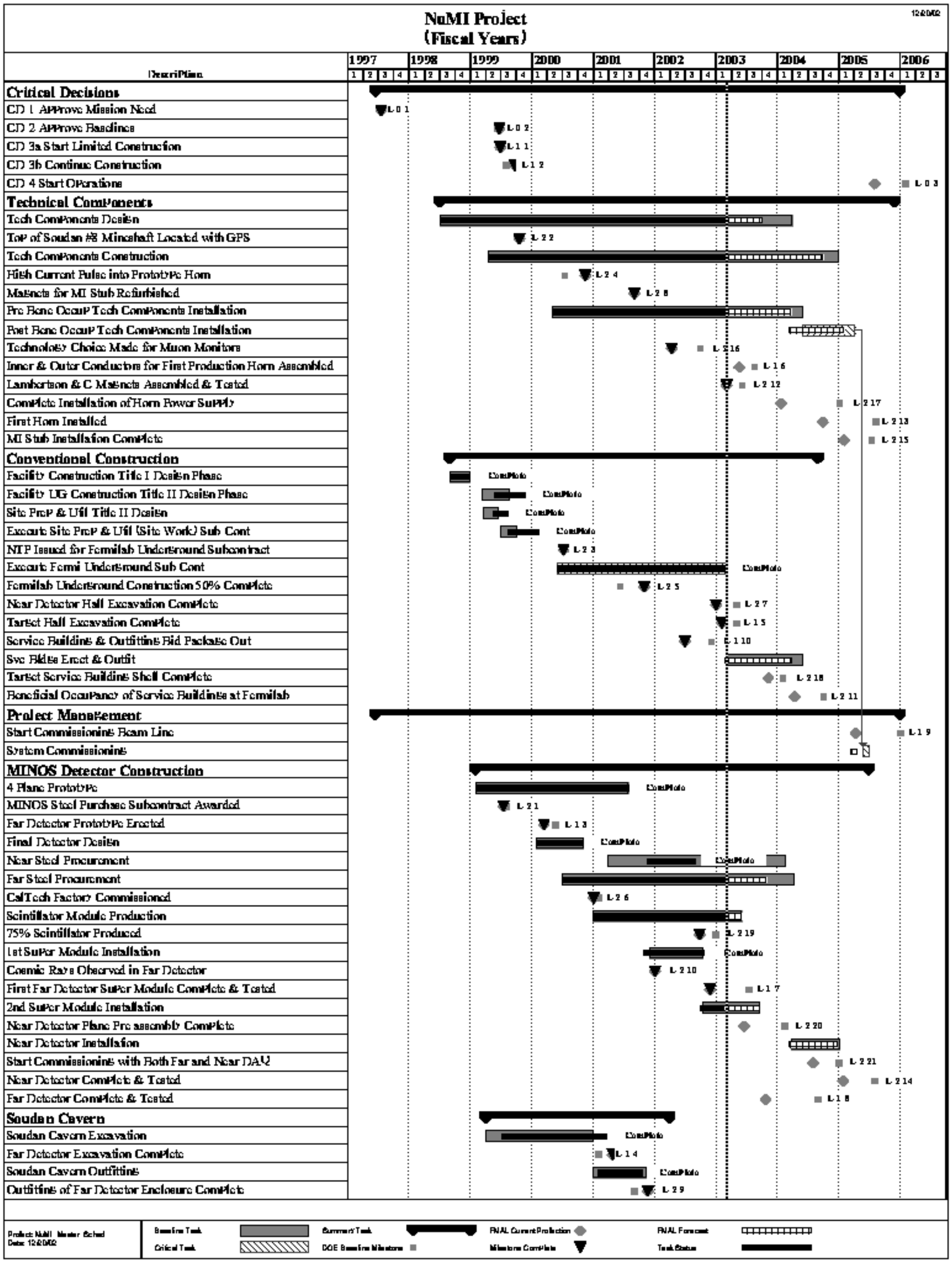

Figure 3 Baseline Master Schedule

CHANGE CONTROL LEVEL	WBS ELEMENT	ITEM	COST (M$)
0		TOTAL PROJECT COST (TPC)	171.4
0	1.0	TOTAL ESTIMATED COST (TEC)	109.2
2	1.1	Technical Components	28.0
2	1.2	Civil Construction	60.5
2	1.3	Project Management	4.8
2		Contingency	16.0
0		OTHER PROJECT COSTS (OPC)	62.2
1	2.0	U.S. Detector Contribution *	38.8
1	3.0	Project Support†	16.1
2		Contingency	7.3

Table 4 Project Cost and Change Control Level by WBS Element

*Does not include United Kingdom contribution of $6.0 million; includes detector installation funds.
†Does not include Minnesota State contribution of $3.8 million.

	Prior Years	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Total
Line Item Funds (TEC)	0	5,500	14,300	22,000	22,949	11,400	20,093	12,500	500	109,242
Other Project Costs	1,417	2,348	4,114	11,324	14,062	19,000	7,435	2,000	500	62,200
Total Project Costs	1,417	7,848	18,414	33,324	37,011	30,400	27,528	14,500	1,000	171,442

Table 5 Planned Funding Profile, in $M.

Note that $2.5M of construction costs appropriated for FY 98 was authorized in FY99 and therefore is included in that column.

6.1 Working Cost & Schedule Plan

The NuMI Project maintains a detailed Working Cost and Schedule forecast that is updated monthly, using new information from subproject managers and from the Fermilab accounting system. The cost and schedule information covers both TEC and OPC funded work, and is included at an appropriate summary level in the monthly report to the DOE. The working schedule shows projected dates for achieving milestones, taking account of actual progress to date.

Responsibility for the collection of information, updating of databases, and report generation is carried by the NuMI Cost and Schedule Administrators.

6.2 Baseline Cost & Schedule Plan

The Baseline CSP is used as the detailed baseline for monitoring and control within the NuMI Project. The cost and schedule information goes down to detailed WBS levels, and uses the same cost and resource-loaded schedule base estimates that were presented at the December 2001 DOE Re-Baseline review. The latest summary of the Baseline Cost Estimate is found in the latest monthly report.

Level 3 milestones are presented in NuMI monthly reports as a basis for comparison with the working schedule. These milestones will be referred to as *NuMI Project Manager Milestones*. The Level 3 milestones are attached as an appendix to this PMP.

Changes to the baseline cost and schedule plan will be made in accordance with the change control process described in Section 7.0.

6.3 Variances

Monthly schedule and cost variances are computed and used as management tools to identify, analyze and rectify significant deviations from the detailed baseline as early as possible.

6.3.1 Definitions

The Budget Cost of Work Scheduled (BCWS) is the time-phased budget that represents the value of the work to be accomplished through a given time. As work is completed, budget associated with this work is "earned" as Budgeted Cost of Work Performed (BCWP) or earned value. The dollar value of the resources consumed in performing the work is represented by the Actual Cost of Work Performed (ACWP).

6.3.2 Schedule Variance Analysis

At the end of each month, the milestone list and critical path tasks are evaluated to identify deviations from the baseline schedule. The schedule variance, measured in dollars, for any subtask is calculated as BCWP – BCWS for that subtask. Any deviations that have a significant impact on the project, either by delaying completion, or by affecting substantially the cost or labor plan of the project, are identified. A plan to rectify such delays will be developed and may include either alterations of the schedule or allocation of additional resources. Such a plan will normally be proposed through a Change Request.

6.3.3 Cost Variance Analysis

The cost variance of any subtask is calculated as BCWP – ACWP. A cost variance that might have a substantial impact on the total cost of a Level 3 subtask will be addressed through the change control process. An analysis of significant cost variances will be included in each monthly report. A plan to resolve significant cost variances may require the assignment of contingency funds and will normally be proposed through a Change Request.

7.0 Change Control Management

Change Control Management refers to the process of proposing, approving, and making any changes to technical, cost and schedule baselines, with consideration of any ES&H impact arising from the proposed changes. The sequence of steps in this process is:

1. Proposing any change. This is done by submitting a Change Request (CR) to the NuMI Project Manager.
2. Approval of the CR. Any CR will be reported to the NuMI Project Manager. If the impact of the requested change exceeds the thresholds described in this section, the NuMI Project Manager will submit it to the PMG for consideration. If the impact of the requested change exceeds the thresholds specified in the PEP, after approval by the Fermilab Directorate, the NuMI Project Manager will submit it to the DOE PM for approval at the appropriate level within DOE.
3. Changing the baseline after approval. This will be done by the NuMI Project Cost and Schedule Administrators. Technical aspects of approved changes will be implemented through technical work plus updating of the relevant sections of the TDRs.

The following sections describe steps 1 and 2 in more detail.

7.1 Making a Change Request

A CR should be submitted by a subtask manager in any of the following kinds of situations:

1. A technical change in the design is proposed which is likely to have any of the following:
    - Significant effects upon the system performance, or require a revision of the TDR.
    - Schedule impact such that a Level 3 milestone on the critical path might be shifted by more than 30 days.

- Schedule impact such that a Level 3 milestone <u>not</u> on the critical path might be shifted by more than 60 days.
- Cost impact at the level of 20% of the subsystem to which the change is to be made.

Note that most technical changes that arise from refinements of Title I designs or from Value Engineering studies are not expected to require CRs.

2. A significant cost baseline change is indicated by a new estimate or because of actual bids on a large purchase, actual experience with work accomplished to date, or accumulation of cost variances in smaller tasks and purchases. "Significant" should be construed in terms of the thresholds defined in Section 7.4, using about 25% of the PMG consideration level.

3. A significant schedule change is indicated, arising from a new estimate or actual bids on key purchases, or experience gained, or accumulation of smaller schedule variances. A threshold of 30/60 days as described above should be used.

4. An administrative change is planned which will require a modification or restructuring of the WBS. Implementing such major changes will require considerable effort by the NuMI Project Support Staff.

CRs should be submitted using a standard form. They will be maintained in an accessible file in the NuMI Project office and will be updated with approval and status information.

7.2 Approval of Change Requests

The following two sections show the baselines and change control thresholds for approval by the Directorate (as advised by the PMG, which functions as the Baseline Change Control Board). If the CR also will affect the DOE Baseline milestones or budgets as given in the PEP, then approval at the appropriate level of the DOE will also be required.

7.3 Technical Baseline Changes

The technical scope of NuMI is defined in the Technical Design Reports. Table 6 lists, for each Level 1 element of the WBS, the document in which the technical baseline is described and examples of technical changes which would require consideration by the PMG. Table 6 is not intended to be a comprehensive list, but rather to illustrate the magnitude of a change in scope that would require such approval.

WBS	Baseline Document	Change Request Thresholds (Examples)	Approval
1.0	NuMI Facility TDR	Major change to the number or type of beamline components, e.g., an additional horn or a lithium lens Changes in the dimensions of the decay pipe exceeding 20 m in length or 20 cm in radius Changes exceeding 10 m in the dimensional specifications of enclosures or surface buildings	Director
2.0	MINOS TDR	Major change in active detector technology Major change in electronics architecture Change in far detector mass exceeding 1 kton.	Director
3.3	MINOS Far Detector Laboratory TDR	Change in cavern dimensions exceeding 10 m Heat load increase exceeding 150 kW	Director & U of MN

Table 6 Technical Baseline Documents and examples of Change Control Thresholds requiring PMG consideration.

7.4 Cost and Schedule Baseline Changes

Cost Changes may involve either the transfer of money only from one WBS element to another (within either the TEC or OPC), or may include the utilization of TEC or OPC contingency. Change control levels for transferals are indicated in Table 3. All contingency is held by the DOE NuMI Project Manager and any utilization of contingency is subject to approval by the DOE NuMI Project Manager, subject only to the $100K accumulation reporting limits discussed below.

Any change exceeding $100K requires PMG consideration and DOE Project Manager approval prior to commitment. For CR's for which the utilization of contingency is less than $100K, the NuMI Project Manager will submit a Change Request for consideration and advisement by the PMG when accumulated cost changes exceed $100K or when accumulated schedule changes cause a Level 3 milestone to be delayed by more than 60 days. The accumulated cost changes are tracked separately for the TEC and the OPC. In practice, the $100K accumulation limit permits the commitment of financial resources from project contingency up to the $100K limit prior to consideration by the PMG or the DOE Project Manager.

Upon approval of a Change Request, the Baseline Cost & Schedule Plan will be revised accordingly. Change control thresholds from Level 0 to Level 4 are shown in Table 3.

7.5 Financial Management and Work Authorization

Budget codes will be established by the Fermilab Budget Office following the WBS structure and assigned at the most appropriate level consistent with the tracking and reporting requirements established for this project. The accumulation of costs in these accounts will be initiated through purchase requisitions (M&S costs) and SWF cost transfers. Purchase requisitions originate with the engineering and scientific staff assigned to the various sub-systems. Signature authority levels will be provided to the Fermilab Business Services Section by the NuMI Project Manager to assure that only authorized work is initiated.

At any time, the contingency for the NuMI Facility Subproject (WBS 1.0) is the difference between the TEC and the current Estimate at Completion (EAC) for the NuMI Facility Subproject. The contingency for the MINOS detector and cavern (WBS 2.0 and 3.0) is the difference between the OPC and the EAC for work related to the MINOS detector and cavern. Release of contingency funds will require approval of the DOE Project Manager.

Authorized work is identified in the CSP. Initiation of authorized work is controlled through the requisition approval process and regular communication within the management structure described in Section 3.0. Monitoring of authorized work is achieved through monthly report documentation and cost report analyses, as well as regular managerial communication.

7.6 Quality Assurance

Quality Assurance is an integral part of the design, procurement, fabrication, construction and installation of all aspects of the NuMI Project.

7.6.1 Quality Assurance Plan

The NuMI Project has developed a Quality Assurance plan that has been implemented in conformance with the Fermilab Director's Policy Manual, dated September 10, 1999. Implementation of the NuMI quality Assurance Plan will be coordinated by the NuMI Quality Assurance Coordinator.

7.6.2 Advance Acquisition Plans

Subsystem managers will develop Advance Acquisition Plans for major purchases. The steel for the MINOS detectors is an example of a major purchase, which is currently being carried out in accordance with an Advance Acquisition Plan.[6] These plans will describe an acquisition strategy which aims to optimize the specifications, delivery schedule, cost, ES&H, QA procedures, or any other factors which may be relevant to the acquisition.

7.6.3 Independent Reviews

Independent assessments comprise a fundamental quality assurance process for the NuMI Project. Such assessments are conducted by groups of qualified individuals to project goals and measure the progress made toward achieving them. The results of such assessments can help to identify problems, suggest solutions and provide for overall improvement. Examples of reviews that are conducted on a periodic basis are reviews by the Fermilab Physics Advisory Committee and semi-annual reviews by the Department of Energy. The Department of Energy will conduct a comprehensive review of the project at intervals of approximately six months. The Fermilab Director will, at his discretion, call for additional reviews of the NuMI Project.

Some reviews may be less broad in scope, focusing on particular aspects of the project. Independent Design Reviews will assess the technical design of the various subsystems and are specifically provided for in the CSP. Furthermore, the NuMI Project Manager may initiate additional design reviews as appropriate. The NuMI Project is also subject to periodic ES&H reviews as described in Section 8.0.

7.6.4 Internal Reviews

Internal Reviews are scheduled as appropriate by the NuMI Facility Manager and the MINOS Manger.

8.0 Environment, Safety and Health

The design, construction, commissioning, operation, and de-commissioning of all NuMI systems will be performed in compliance with the standards in the Fermilab ES&H Manual, and all applicable ES&H standards in the Laboratory's "Work Smart Standards" set. In addition, all related work will be performed in compliance with applicable federal, state and local regulations.

8.1 ES&H Organizations

The Fermilab Environment, Safety & Health Section provides ES&H support for all activities at Fermilab, including guidance on ES&H issues, environmental monitoring and safety assessments. The NuMI Project will develop an MOU with the ES&H Section, which will specify the roles and responsibilities of each organization in the area of ES&H during both the construction phase and the operational phase of the project.

The Beams Division Shielding Review Committee is responsible for reviewing the results of shielding assessments with regard to methodology and compliance with the Fermilab Radiological Control Manual. In addition, both the Beams Division and the Particle Physics Division have appointed Safety Review Committees specifically for the NuMI Project.

8.1.1 NuMI Facility Safety Review Committee

The NuMI Facility Safety Review Committee is appointed by the BD Head to ensure that the NuMI line organization develops the NuMI Facility in accordance with applicable ES&H regulations, standards and good practices.

8.1.2 MINOS ES&H Review Committee

The MINOS ES&H Review Committee is appointed by the PPD Head to ensure that the MINOS Subproject complies with Fermilab ES&H requirements. The Committee will not consider matters of safety at Soudan, since the University of Minnesota is responsible for all ES&H matters there and has developed a separate plan to address them.[7] The MINOS ES&H Review Committee is composed of experts in area such as mechanical and electrical engineering, laser safety, fire protection, and other potential hazards encountered in high energy physics experiments.

8.1.3 ES&H Responsibilities of the NuMI Project Staff

Fermilab follows Integrated Safety Management. Each person on the NuMI staff is responsible for following good ES&H practices in the course of his or her own work. However, in addition to these ordinary responsibilities, the NuMI Project management has a dedicated NuMI ES&H Coordinator. Because the safety issues in NuMI Project spans over many different areas, there are three special ES&H assignments within the NuMI Project: The NuMI Conventional Safety Coordinator, the NuMI Civil Construction ES&H Coordinator, and the NuMI Radiation Safety Coordinator.

8.1.3.1 NuMI ES&H Coordinator

This person coordinates the administrative aspects of all ES&H work carried out in the NuMI Project and reports to the NuMI Project Manager. The ES&H Coordinator compiles and maintains the NuMI Safety Assessment Document (SAD) [see Section 8.2.2].

8.1.3.2 NuMI Conventional Safety Coordinator

The NuMI Conventional Safety Coordinators carry project responsibility for ES&H aspects of NuMI and MINOS conventional safety activity at Fermilab and Soudan. The two most important aspects are:

- Address safety features of the designs of beamline and detector components
- Worker safety during installation of beamline and detector components

8.1.3.3 NuMI Civil Construction ES&H Coordinator

This person carries project responsibility for ES&H aspects of NuMI civil construction activity on the Fermilab site. The three most important aspects are:

- Life safety features of the construction design
- Worker safety during actual construction
- Environmental protection during civil construction.

8.1.3.4 NuMI Radiation Safety Coordinator

This person carries the responsibility for supervising the continuing study and documentation of radiological safety issues for NuMI. These are described in detail in Reference 1.

8.2 ES&H Documentation

Specific documentation related to ES&H matters for the NuMI Project is described in the following sections.

8.2.1 Environmental Assessment

Fermilab has conducted an Environmental Assessment of the potential environmental consequences of the NuMI Project at the Fermilab site. This was supplemented by an Environmental Assessment Worksheet (EAW) prepared the Minnesota Department of Natural Resources in accordance with the regulations of the State of Minnesota. The EAW assessed the potential environmental consequences of the work at Soudan and is incorporated into the NuMI Environmental Assessment. A Finding of No Significant Impact (FONSI) was issued by the DOE on January 16, 1998. The FONSI is an attachment to the PEP.

8.2.2 Safety Assessment Documents

Fermilab has developed a Preliminary Safety Assessment Document (PSAD) for the NuMI Project, which was approved on December 22, 1998. The PSAD identifies the ES&H issues associated with the NuMI Project at Fermilab and indicates that it is possible to address them in such a way that the ES&H impact of NuMI is minimal. The approved PSAD will form the basis of the NuMI Safety Assessment Document (SAD), which will describe in detail how each of these issues has been addressed. The SAD will be completed under the direction of the NuMI ES&H Coordinator and reviewed on a section-by-section basis as the various detailed design decisions relating to ES&H are made.

As set forth in the MOU between Fermilab and the University of Minnesota, the University of Minnesota is responsible for addressing ES&H at the Soudan Underground Laboratory in accordance with reference 7.

8.2.3 Life Safety Assessment

Fermilab has contracted the services of Gage-Babcock & Associates, Inc. to perform an assessment of life safety issues for the NuMI Project at the Fermilab site. The assessment focused on underground life safety. The report[8] from Gage-Babcock addresses means of egress, fire protection, and emergency preparedness. The engineering firm contracted to design the underground facility on the Fermilab site will incorporate the Gage-Babcock recommendations.

8.2.4 Radiation Safety

Details of calculations and designs to ensure radiological protection of personnel, the public and the environment at the Fermilab site are described in Chapter 4 of the NuMI Facility Technical Design Report. Further work will provide the basis for shielding reviews by the Fermilab Beams Division and ES&H Section. Refinement of these calculations will be carried out under the direction of the NuMI Radiation Safety Coordinator. There are no significant issues of radiological safety at the Soudan site.

References

[1] The NuMI Project Staff, *The NuMI Facility Technical Design Report, Version 1.0*, October 1998 and *The NuMI Technical Design Handbook*, 2002.

[2] The MINOS Collaboration, *The MINOS Detectors Technical Design Report, Version 1.0*, October 1998

[3] The University of Minnesota; CNA Consulting Engineers; Erickson-Ellison Associates, Inc.; Miller-Dunwiddie, Inc.; *MINOS Far Detector Laboratory Technical Design Report (Including Basis of Estimate and WBS) for Cavern Construction, Cavern Outfitting & Detector Outfitting*, NuMI-L-263, October 1998

[4] The NuMI Project Staff and The MINOS Collaboration, *Summary of the NuMI Project*, October 2001

[5] The NuMI Project Staff, *The NuMI Project Cost & Schedule Plan*, October 2001

[6] *Advanced Procurement Plan for MINOS Steel*. October 1998

[7] University of Minnesota, CNA Consulting Engineers, Erickson-Ellison Associates, Inc. Miller-Dunwiddie, Inc., *MINOS Far Detector Laboratory Project Hazard Report and Safety Plan*, UM Project No. 896-95-1634, NuMI-L-419, November 1998

[8] Gage-Babcock & Associates, Inc., *Fire Protection/Life Safety Recommendations for the Fermilab NuMI Project*. October 1998

Appendix A

Level 3 Milestones

This appendix lists the remaining Level 3 milestones for the NuMI Project as of December 31, 2002. Milestone status is maintained in the NuMI Project office.

Milestone #	WBS	Name	Baseline Finish
L-3-159	1.1.1.0.1.6	Stub Major Magnet Stands Design & Drawings Compl	4/11/03
L-3-157	1.1.1.0.1.8	Kicker Magnet & Cooling Syst Design & Dwgs Compl	5/8/03
L-3-219	1.1.1.0.2.2	Extraction Devices Ready for Installation	4/30/04
L-3-251	1.1.1.0.2.8	Extraction & Primary Beam Instru Construction Compl	6/25/04
L-3-230	1.1.1.0.2.13	Kicker Ready to Install	4/30/04
L-3-215	1.1.1.0.2.19	Lambertson Magnet Installation Complete	7/23/04
L-3-237	1.1.1.0.3.1	Pre-Target Equip Stands Ready for Installation	11/3/03
L-3-271	1.1.1.0.3.2	Target Interface Baffle/Window Ready for Install	4/9/04
L-3-252	1.1.1.0.3.3	Instrumentation Ready for Installation	3/5/04
L-3-291	1.1.1.0.3.4	MI Stub Installation Complete	10/13/04
L-3-278	1.1.1.0.3.5	Pre-Target Installation Complete	10/22/04
L-3-299	1.1.1.0.4	Extraction & Primary Beam Pre-Commissioned	10/29/04
L-3-196	1.1.2.0.2.3	Production Target Fabrication Complete	12/19/03
L-3-174	1.1.2.0.4.2.1	Production Horn 1 Assembly Complete	8/7/03
L-3-194	1.1.2.0.4.2.4	Assembly of Horn 1 Module Complete	10/7/03
L-3-216	1.1.2.0.4.2.5	Assembly of Horn 2 Module Complete	2/26/04
L-3-212	1.1.2.0.4.2.6	Final Assy of Horn 1 & Module Complete	2/13/04
L-3-156	1.1.2.0.4.2.9	Production Horn 2 Assembly Complete	5/1/03
L-3-152	1.1.2.0.4.2.11	Horn 1 Inner Conductor Welding Compl	4/7/03
L-3-235	1.1.2.0.4.2.12	Assy of Target/Baffle Module Complete	2/25/04
L-3-300	1.1.2.0.4.2.13	Final Assy of Horn 2 & Module Complete	5/5/04
L-3-301	1.1.2.0.4.2.14	Final Assy of Target Baffle on Module Complete	5/27/04
L-3-197	1.1.2.0.4.3.2	Complete Horn 1 Operational Testing in Test Stand	12/5/03
L-3-190	1.1.2.0.4.3.3	Complete Horn 2 Operational Testing in Test Stand	8/22/03
L-3-254	1.1.2.0.4.4.2	Compl Placement of Horn 1 Assy into Target Station	7/12/04
L-3-295	1.1.2.0.4.4.4	Pulse & Pre-Commission Horn System Complete	11/26/04
L-3-270	1.1.2.0.5.6	Target & Horn Installation Complete	10/5/04

L-3-158	1.1.2.0.5.7	Lower Chase Shielding Fab & Installation Dwg Set Compl	5/26/03
L-3-290	1.1.2.0.5.9	Shielding Installation Complete (Pre-Hot Handling)	11/11/04
L-3-171	1.1.2.0.5.12	Upper Chase Shielding Fab & Installation Dwg Set Compl	9/29/03
L-3-277	1.1.3.0.1.1.2	Compl Install & Testing of Kicker PS	8/16/04
L-3-172	1.1.3.0.1.1.9	Kicker Power Supply Design & Dwgs Compl	7/17/03
L-3-195	1.1.3.0.1.1.10	Kicker Power Supply Construction Complete	11/12/03
L-3-274	1.1.3.0.1.3.5	Power Test of TH Conventional Power Supplies Compl	7/15/04
L-3-199	1.1.3.0.2.10	Compl Install of Horn Power Supply in PS Room	2/16/04
L-3-250	1.1.3.0.2.16	Power Supply Refurbishing Complete	4/2/04
L-3-170	1.1.3.0.2.17	Transmission Line Design & Dwgs Compl	8/15/03
L-3-276	1.1.3.0.3.7	Complete Assy/Installation of Stripline	7/21/04
L-3-173	1.1.4.0.1.6	Purch Order for Core Modules, Aluminum Submitted	7/15/03
L-3-232	1.1.4.0.1.8	Start Absorber Installation	4/2/04
L-3-238	1.1.4.0.1.9	All Hadron Absorber Core Material Delivered	5/19/04
L-3-178	1.1.4.0.1.13	Core Backshielding Steel Fabricated	11/28/03
L-3-256	1.1.4.0.1.14	Assy of Core on Carrier Complete	10/19/04
L-3-294	1.1.4.0.1.15	Precommission Absorber	12/30/04
L-3-210	1.1.4.0.2.4	Start of U.S. Vacuum Endcap Installation	3/15/04
L-3-239	1.1.4.0.2.6	Test of Vacuum Integrity	9/1/04
L-3-213	1.1.5.0.MS.2	Muon Monitors Ready for Installation	3/19/04
L-3-255	1.1.5.0.MS.3	Muon Monitors Installed	8/13/04
L-3-296	1.1.5.0.MS.4	Muon Monitors Operational	12/20/04
L-3-217	1.1.5.0.MS.10	Downstream Hadron Monitors Ready for Installation	4/7/04
L-3-258	1.1.5.0.MS.11	Downstream Hadron Monitor Installed	6/21/04
L-3-297	1.1.5.0.MS.12	Downstream Hadron Monitor Operational	12/28/04
L-3-236	1.1.6.0.2	Network in Target Hall	6/17/04
L-3-192	1.1.7.0.1.5	U.S. LCW Syst Piping & Equip Installed in MI-62	11/7/03
L-3-231	1.1.7.0.1.6	All Water System Skids Installed in Enclosures	7/16/04
L-3-272	1.1.7.0.1.8	All Water Systems Precommissioned	10/25/04
L-3-153	1.1.7.0.1.10	RAW Systems Engineering Notes Sent for Review	9/30/03
L-3-298	1.1.7.0.2.3	Vacuum Systems Precommissioned	12/10/04
L-3-155	1.1.8.0.2.1	L3 Managers Review of Controls Syst Design Compl	10/10/03
L-3-279	1.1.8.0.2.3	Controls Installation Complete	11/19/04
L-3-259	1.1.8.0.3.3	Personnel Safety Interlock System Installation Complete	10/20/04
L-3-176	1.1.8.0.4.1	Cable System Specifications Complete	8/18/03
L-3-257	1.1.8.0.4.3	MI60 Cable Syst Install Compl (Excl Trim Elements)	8/20/04

L-3-293	1.1.8.0.4.4	MI-62 Cable System Installation Complete	9/17/04
L-3-253	1.1.8.0.4.5	Pre-Targ Hall & Targ Hall Cable Syst Installation Compl	7/26/04
L-3-214	1.1.8.0.4.7	FIRUS Cable System Installation Complete	5/31/04
L-3-234	1.1.8.0.4.8	Fiber Optic Cable Installation Complete	3/16/04
L-3-175	1.1.8.0.4.10	Sub Req for Shaft Cables for SB&O Installation	6/2/03
L-3-198	1.2.0.7	Beneficial Occupancy of UG Target Area	11/18/03
L-3-218	1.2.0.8	B. O. of MINOS Shaft, Absorber, MINOS Tunnel & MINOS Hall	2/12/04
L-3-191	1.2.0.12	Target Service Bldg Shell Complete	8/15/03
L-3-177	1.2.0.13	Service Bldg Foundations Complete	5/23/03
L-3-179	1.2.0.14	Pit Liner Complete	7/7/03
L-3-193	1.2.0.14	MSB Shell Complete	9/19/03
L-3-211	1.2.0.15	MINOS Service Bldg Complete	2/12/04

Appendix B
Level 0, 1, 2 Milestones from NuMI PEP

Level 0 Milestones

Milestone No.	Description	Baseline Date	Actual Date
L-0-1	CD-1: Approve mission need	03-97	03-17-97
L-0-2	CD-2: Approve baselines	02-99	02-17-99
L-0-3	CD-4: Start operations	09-05	

Level 1 Milestones

Milestone No.	Description	Baseline Date	Actual Date
L-1-1	CD-3a: Start limited construction	02-99	02-23-99
L-1-2	CD-3b: Continue construction	04-99	05-21-99
L-1-3	Far detector prototype erected	01-00	11-10-99
L-1-4	Far detector excavation complete	10-00	12-22-00
L-1-5	Target hall excavation complete	12-02	
L-1-6	Inner and outer conductors for first production horn assembled	04-03	
L-1-7	First far-detector super module complete and tested	03-03	
L-1-8	Far detector complete and tested	04-04	
L-1-9	Start commissioning beamline	09-05	

L-1-10	Service building & outfitting bid package out	07-02	

Level 2 Milestones

Milestone No.	Description	Baseline Date	Actual Date
L-2-1	MINOS steel purchase subcontract awarded	04-99	03-15-99
L-2-2	Top of Soudan #8 mineshaft located with GPS	06-99	06-16-99
L-2-3	NTP issued for Fermilab underground subcontract	03-00	03-06-00
L-2-4	High current pulse into prototype horn	03-00	07-14-00
L-2-5	Fermilab underground construction 50% complete	02-01	06-29-01
L-2-6	CalTech factory commissioned	09-00	09-01-00
L-2-7	Near detector excavation complete	12-02	
L-2-8	Magnets for MI stub refurbished	04-01	04-30-01
L-2-9	Outfitting of far detector enclosure complete	04-01	07-19-01
L-2-10	Cosmic rays observed in far detector	09-01	09-03-01
L-2-11	Beneficial occupancy of service buildings at Fermilab	05-04	
L-2-12	Lambertson and C-magnets assembled and tested	02-03	
L-2-13	First horn installed	04-05	
L-2-14	Near detector complete and tested	03-05	
L-2-15	MI stub installation complete	03-05	

L-2-16	Technology choice made for muon monitors	05-02	
L-2-17	Complete installation of horn power supply	09-04	
L-2-18	Target Service Building Shell Complete	09-03	
L-2-19	75% scintillator produced	08-02	
L-2-20	Near detector plane pre-assembly complete	10-03	
L-2-21	Start commissioning with both Near and Far DAQ	08-04	